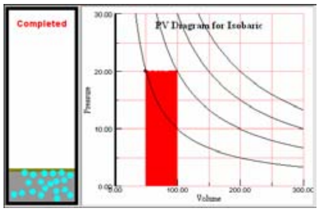
Worksheet for Exploration 20.5: PV Diagrams and Work



Ideal gas law: PV = nRT. **In this animation N = nR** (i.e., k_B = 1). This, then, gives the ideal gas law as PV = NT. The work done during a thermodynamic process depends on the type of process (and can be positive, negative, or zero). Restart. Work is given by the equation

$$W = \int P\, dV,$$

so that on a pressure-volume diagram, the area under the curve is the work done **by the gas** during the expansion. In order to analytically solve for the work, you need to know how pressure depends on volume (is pressure constant, changing linearly with volume, etc.?). How pressure varies with volume depends on the type of process (isothermal, isobaric, isochoric, adiabatic).

The three animations show three different processes that start at a common temperature and end at a common temperature.

a. What is the change in internal energy (ΔU) for these processes (remember that ΔU = (3/2)nRΔT = (3/2)NΔT for an ideal monatomic gas)?
   i. Careful on the sign.

ΔU=_______

b. Estimate the area under the curve (count the blocks on the graph) when the system goes from one temperature to another (from one isotherm on the graph to another). This is the value of the work done since work is W = ∫ PdV. Which process does positive work? Which process does negative work? Which process does zero work?

Work(Isobaric)=_______

Work(Isochoric)=_______

Work(Adiabatic)=_______

c. The first law of thermodynamics, $\Delta U = Q - W$, when written as, $Q = W + \Delta U$, says that the heat into a system can be used to do work and/or increase the internal energy. Therefore, which process requires the most heat?

Process=______________________

d. Compare the area under the curve that you estimated in (b) with the value you calculate using the equations below (found by using calculus and solving the integral):

i. Constant pressure: $W = P(V_f - V_i)$

ii. Adiabatic: $W = (P_f V_f - P_i V_i)/(1-\gamma)$, where γ (the ratio of C_P/C_V, specific heat at a constant pressure divided by the specific heat at a constant volume) for an ideal monatomic gas is 5/3.